5 Evaluation of Alternatives

5.1 Introduction

A variety of alternatives have been developed to address the purpose and need of this project. This Chapter includes information relative to the evaluation of each of the alternatives presented in Chapters 3 and 4, along with the rationale for eliminating certain alternatives from further study. The process for evaluation and review of alternatives used throughout this project is also presented.

5.2 Alternatives Review Process

The I-93 corridor study has a set process in place for review and input of project related information. A number of meetings were held by the NHDOT as the project progressed from conceptual ideas through eventual plans, analysis and reports. This section describes the variety of meetings conducted as part of this review process, during which, information was presented or distributed to the various agencies or general public in attendance.

5.2.1 Technical Review

The NHDOT and the FHWA are the responsible state and federal agencies for technical oversight and development of the EIS for the I-93 project. Together, these agencies make up the foundation for the technical review for this project, particularly in the case of transportation issues. In addition, technical review and input is sought from the Federal Transit Administration, Regional Planning Commissions, and technical staff that reside with the local communities. Technical review activities serve as a preliminary forum to consider all project related materials, ideas and design concepts developed.

Technical review meetings are held as required, throughout the life of the project, to review project related information and solicit input. In turn, revisions are made or additional studies are conducted, as appropriate, to supplement the study process.

5.2.2 State and Federal Resource Agencies

Another level of review includes both federal and state environmental Resource Agencies. These agencies are responsible for making or influencing permitting decisions based on state and federal laws and regulations, and ultimately serve to protect natural, cultural, and socio-economic environmental resources potentially affected by the project. The agencies are focused on assuring the least impacts, while providing practicable solution that meets the project purpose and need.
State resource agencies involved in this project include:

State Agency	State Level Responsibility
NH Department of Environmental Services	Wetlands, Air, Water Quality
NH Natural Heritage Inventory	Threatened or Endangered Plant Species
NH Division of Historical Resources	Historical and Archeological Resources
NH Office of State Planning	Floodplains, Land Use Planning
NH Office of Emergency Management	Floodplains
NH Fish & Game Department	Fisheries, Wildlife, Threatened or Endangered Wildlife Species

Federal resource agencies involved in this project include:

Federal Agency	Federal Level Responsibility
US Environmental Protection Agency – Region 1	Wetlands, Air, Water Quality
US Army Corps of Engineers – N.E. District	Wetlands, Water Quality, Historic and Archeological Resources
US Fish & Wildlife Service	Fisheries, Wildlife, Threatened or Endangered Species
US Federal Emergency Management Agency	Floodplains

The I-93 project has been identified as a high priority project by the NH State Legislature via HB1106 because of the importance of this highway corridor to the region and New Hampshire. In addition, US Senator Bob Smith is sponsoring an effort to streamline the environmental permitting process, so that improvements may be constructed and implemented as soon as possible. The "Environmental Streamlining" process is being coordinated by the NHDOT and the FHWA with assistance from Senator Smith's office and the Senate Committee on Public Works and Environment. (More information can be found about Environmental Streamlining by visiting the FHWA website at www.fhwa.dot.gov/environment/strmlng.htm)

In an effort to allow the public to interact with and understand the Resource Agencies' perspective as to what should be done for transportation infrastructure

improvements for the I-93 corridor, monthly Resource Agency meetings, normally held at NHDOT headquarters in Concord, are now being held along the project corridor. Information related to the study is presented and distributed at these meetings. The meetings are open to the general public and public participation is encouraged. Additional meetings have also been held with the Resource Agencies as part of the streamlining process. These meetings also result in revisions or additional studies, as appropriate, to address comments solicited from these agencies.

A total of eight Resource Agency meetings have been held to date with three additional meetings held to establish and coordinate the Environmental Streamlining process. Actual dates and locations of these meetings are listed in Appendix A of this report along with the topics of discussion.

In addition to these Resource Agency meetings, a second Scoping Meeting was held on December 6, 2000. The first Scoping Meeting was held in May, 1992. This second Scoping Meeting was held to provide an opportunity to formally take comment on the purpose and need of the project, the study area under consideration, the alternatives being considered and the key issues involved. The Resource Agencies, Public Officials, and the general public were invited to attend.

5.2.3 Advisory Task Force

An Advisory Task Force (ATF) was established early in the project process. The I-93 ATF is made up of two people, appointed by each of the five communities, through which I-93 passes, and one person appointed by each of the three Regional Planning Commissions, whose regions are affected by the project.

ATF meetings have been held on a regular basis since March 2000, approximately every four to six weeks, to present and distribute project related information. The meetings are held in the evenings, are open to the general public and public participation is encouraged. The role of the task force is to collect input from the Towns they represent, and provide input and help guide the NHDOT in developing a comprehensive solution that will balance the needs of the community and the region, with the purpose and need of the project.

Eight ATF meetings have been held to date within the five communities along the corridor. Actual dates and locations of these meetings are listed in Appendix A of this report along with the topics of discussion.

5.2.4 Public Officials

Meetings with local and regional, appointed and elected public officials of the five communities directly affected are held periodically to review project findings, status, and schedule. In general, Public Officials Meetings are held at specific milestones, throughout the life of the project, to review project-related information and solicit input from each of the communities. Revisions and additional studies, as appropriate, are conducted to address comments received.

Two rounds of public officials meetings have taken place for this project. A first series of meetings with each of the five communities were held in March, 2000 to present the study area for the corridor and discuss the issues of concern and alternatives to be studied. These meetings were held in the evenings and the general public was invited to attend.

Recently, during the months of November and December, 2000, a second round of meetings were held in the communities to discuss study findings relative to alternative mode of transportation and present the concept plans for widening the highway and improving the interchanges. As with the first round, meetings were held in the evening and officials and the public were invited to attend.

In all, ten Public Officials Meetings have been held to date within the five communities along the corridor. Actual dates and locations of these meetings are listed in Appendix A of this report along with topics of discussion.

5.3 Evaluation of Alternatives

This section outlines the criteria used to evaluate the alternatives. This section also includes a discussion on Environmental Considerations and what and how they will be evaluated, an evaluation of Alternative Modes of Transportation, and a discussion on Highway Safety and Capacity. The No Build Alternative will be carried forward into the DEIS and used as a base line for comparison with the alternatives carried forward into the DEIS.

5.3.1 Environmental Considerations

In developing the conceptual alternatives, environmental (natural, cultural, and socio-economic resources) and engineering constraints were considered. Environmental mapping and data based on available mapping, project research, and field investigations, as outlined in the Scoping Report, was used to identify constraints. The conceptual layouts of the I-93 mainline and interchange alternatives looked to first avoid environmental resources within the engineering constraints of

widening the existing I-93 corridor. That is, the mainline alignments were shifted to the east or west, within interstate geometric design and constructability parameters, to avoid or minimize impacts to important resources and properties. Areas that exhibited substantial or unmitigable impacts were noted.

At this Phase of the alternatives development, the concepts are at a macro level and the designs are essentially two-dimensional in nature, except at certain locations. Critical cross sections were developed to better understand the potential impacts and engineering issues. Resource impacts were not quantified, except by observation for comparison, that one concept would probably have greater impacts than another. Resources considered as important environmental constraints that will influence the design and selection of alternatives include the following:

5.3.1.1 Surface Water Resources

The Canobie Lake Watershed will be of particular concern, because the Lake serves as Salem's water supply. In addition, the Cobbetts Pond watershed will be of concern as an important recreational resource in the Town of Windham. Other lakes, ponds, and streams will also be of concern relative to water quality, with many of the area waterbodies and watercourses having recreational and other values to the communities in the region. Several of the watercourses fall within conservation zones under local ordinances. The Windham Watershed Protection Area is also a primary concern.

The potential for stormwater delivery of pollutants to surface waters is a general concern throughout the I-93 corridor. In particular, Canobie Lake, a Class A waterbody serving as the water supply to the Town of Salem, and Cobbetts Pond are potential receptors of non-point inputs of road runoff due to its proximity to the corridor. In addition to the potential for non-point inputs to these lakes, there are tributaries to these waterbodies that serve as potential pathways for delivery of drainage derived from an extensive section of I-93.

5.3.1.2 Floodplains

Project Alternatives may affect some portion of one or more of the floodplain areas that exist within the five communities through which I-93 passes. Therefore, an evaluation of potential impacts on floodplains is required under the provisions of Executive Order 11988, "Floodplain Management," 23 CFR 650A, and the National Flood Insurance Program (NFIP).

The Spicket River and its tributaries in the Town of Salem will be of special concern relative to flooding because of a history of flooding problems both within the Study Area (in New Hampshire) and in downstream communities in Massachusetts. Flood

impacts along this river system extend from Salem to Methuen and Lawrence, Massachusetts. Primary valley storage is provided along the section of this river that parallels I-93 near the Massachusetts border. This storage could be affected by widening the highway.

Beaver Brook and Cohas Brook also have floodplains and floodways that may be directly affected by improvements to the existing highway.

5.3.1.3 Groundwater

Most public and community water supplies fall outside the immediate corridor of the existing highway. However, the potential for road salt contamination of nearby wells is a general concern throughout the I-93 corridor. Additionally, there are a number of specific locations where protection of groundwater is an issue. These include the following locations:

- Windham community water supply well between Canobie Lake and I-93
- Proximity to Canobie Lake (Class A water body serving as water supply for the Town of Salem) and surrounding watershed
- The joint Wellhead and Watershed Protection Areas established by the Towns of Salem and Windham.
- The Groundwater Resources Conservation District established by the Town of Derry.

5.3.1.4 Air Quality

Widening of major transportation corridors needs to meet regional air quality conformity requirements. For traffic-related impacts, the pollutants of interest are carbon monoxide and ozone. The primary concerns will be:

1. whether the proposed roadway alternatives will create or exacerbate violations of carbon monoxide (CO) standards, and
2. whether the proposed action will increase or decrease the regional emissions of ozone precursors [primarily volatile organic compounds (VOCs) and nitrogen oxides (NOx)].

5.3.1.5 Noise

The noise analysis is designed to indicate the magnitude and extent to which noise-sensitive receptors would experience changes in traffic noise due to highway improvements. A number of neighborhoods exist in close proximity to the highway, and noise attenuation will be considered for these areas.

5.3.1.6 Wetlands

Wetlands are recognized to be an important resource for which impacts must be avoided to the maximum extent practicable, and those wetland impacts that cannot be avoided must be minimized and mitigation for the impacts must be provided. Wetlands that are considered particularly important are those associated with Porcupine Brook in Salem, a heron rookery in Windham, Wheeler Pond in Londonderry, and Cohas Brook in Manchester.

In addition to complying with federal and state wetland requirements, I-93 must be designed to avoid substantial impacts to "Prime Wetlands" at the local level. Wetlands so designated as prime carry special consideration relative to impacts and mitigation. Prime wetlands potentially impacted by the I-93 improvements are located in Salem and Derry.

5.3.1.7 Vegetation and Wildlife Habitat

Concerns relative to wildlife along the I-93 corridor principally involve consideration of maintaining and improving corridors of wildlife habitat to the extent possible. Specific areas of interest include the marsh at the junction of I-293 and I-93 (an important habitat for waterfowl, wading birds, and aquatic mammals); the riparian wetland system along Cohas Brook (with consideration of wildlife passage under the highway); and the great blue heron rookery near the SB weigh station in Windham.

5.3.1.8 Socio-economic Impacts

Socio-economic impacts involve direct impacts to people's homes, businesses, and work places, and indirect impacts affecting access, land use, setting, travel patterns, safety, and local and regional economies. For the most part, direct impacts create hardships and need to be avoided or minimized to the extent practicable. Indirect impacts are more difficult to estimate and evaluate, and result in benefits or problems that are long-term in nature. Socio-economic issues of primary concern involve minimizing impacts to private property, while building into the proposed layout enough planning to assure the I-93 corridor can continue to service the transportation needs of the region long into the future.

5.3.1.9 Cultural Resources

Archeological Sites and Historic Sites

Archeological and historic sites are scattered along and within the highway corridor the length of the project. Sites of particular importance include the potentially historic district along NH 111-A and the Searles Castle property, both in Windham.

Further research will also be required with the proposed park and ride sites at Exit 2 and Exit 5.

Public Lands

Public lands of particular concern would be those that fall under the 4(f) and 6(f) qualification. Section 4(f) of the Department of Transportation Act of 1966 states "… special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges and historic sites." There are several 4(f) land parcels within, and surrounding the I-93 study area. However, given the distance of these parcels from the proposed conceptual highway improvements, it is unlikely that any of these parcels will be impacted.

Section 6(f) lands are defined as lands that have been acquired or improved with funds provided by the federal Land and Water Conservation Act. A review of DRED's files indicate that two properties located in the I-93 Study Area qualify as Section 6(f) properties; they are Hedgehog Park in Salem and Crystal Lake Park in Manchester. Based on preliminary review of the proposed conceptual highway improvements, it is unlikely that these properties will be impacted.

One site of additional concern is property adjacent to the Exit 4 park and ride lot, which is proposed to be used for expanding the existing park and ride lot to accommodate future rail service in the Exit 4 area. This area has been identified, through comments at public meetings, as a potential 6(f) property and will need to be investigated further.

5.3.2 Alternative Modes of Transportation

As described in Chapter 3, ridership was projected for the individual rail, bus and HOV lane options. Based on the results of those projections, the individual rail, bus, and HOV options along with various highway widening configurations were assembled into 14 combinations. These mode combinations were designed to test the interactive affect of the various options.

The purpose of the analysis of mode combinations was to determine what combinations would attract the greatest ridership and divert the largest number of drivers from I-93. These diversions were then analyzed to determine their effect on the need for highway improvements. Specifically, the highway level of service with these mode combinations was calculated to determine if a desired level of service on the highway could be achieved with a more limited set of highway improvements. The results of the level of service analyses are presented in the next section (5.3.3) of this report.

5.3.2.1 Description of Alternative Mode Combinations Analyzed

Table 5.3-1 defines how the individual mode options described in Chapter 3 were combined. The table includes an identification number for each combination of modes, the number of general purpose lanes provided on I-93, and a check mark to indicate which of the individual bus, rail, and HOV options are included. The individual options included in the mode combinations are:

- An HOV lane in New Hampshire and Massachusetts between I-293 in New Hampshire and I-95 (Route 128) in Massachusetts
- Expanded Bus serving downtown Boston
- Enhanced Bus serving I-93 employment centers in northern Massachusetts
- Bus Subsidy
- I-93 Enhanced Rail in the I-93 median between Exit 5 in New Hampshire and the Woburn Transportation Center in Massachusetts
- West Rail Corridor between Manchester and Nashua
- East Rail Corridor between Manchester and Lawrence, Massachusetts

Table 5.3-1
Rail, Bus, HOV Lane Mode Combinations

Mode Combination ID Number	Number of General Purpose Lanes[A]	HOV Lane[B]	Expanded Bus	Enhanced Bus	Bus Subsidy	Enhanced I-93 Rail	West Rail	East Rail
1	2						✓	
2	2							✓
3	2					✓		
4	2	✓	✓	✓				
5	2	✓	✓	✓	✓		✓	
6	3		✓	✓				
7	3	✓	✓	✓				
8	3		✓	✓	✓		✓	
9	3	✓	✓	✓	✓		✓	
10	4		✓	✓				
11	2	✓		✓	✓			✓
12	3	✓		✓	✓			✓
13	2					✓		✓
14	3	✓	✓	✓	✓	✓		

A: Number of general purpose lanes in each direction north of Exit 1. Two lanes in each direction represents the highway no-build condition except for the segment of I-93 south of Exit 1 which currently has three general purpose lanes in each direction.

B: The HOV lane is a third lane in addition to the existing two general purpose lanes for Alternatives 4 and 5 and a fourth lane for Alternatives 7 and 9. It extends from south of I-293 to I-95 (Route 128) in Massachusetts.

The following provides an explanation of each of the mode combinations tested:

- Combinations 1-3 test the West, East, and I-93 Enhanced Rail modes, respectively, with no highway widening (i.e., two general purpose highway lanes

in each direction). Rail ridership is expected to be at its highest with no highway widening because highway congestion will be at its worst, resulting in motorists more willing to seek alternative modes of travel.

- Combinations 4-5 also assume no additional highway general purpose lanes and test Expanded and Enhanced bus services with an HOV lane. Mode combination 5 also includes a bus subsidy and the West Rail.

- Combination 6 is the same as Combination 4 except that it replaces the HOV lane with a general purpose lane.

- Combination 7 adds an HOV lane to Combination 6.

- Combination 8 is the same as Combination 5 except that it replaces the HOV lane with a general purpose lane.

- Combination 9 adds an HOV lane to Combination 8.

- Combination 10 adds another general purpose lane to Combination 6.

- Combinations 11 and 12 combine Enhanced Bus (service to northern Massachusetts), a bus subsidy, an HOV lane, and East Rail (service to Boston) with two and three general purpose lanes, respectively.

- Combination 13 tests Enhanced Rail with East Rail and assumes no highway widening.

- Combination 14 combines both bus services, an HOV lane, a bus subsidy, and Enhanced Rail with three general purpose highway lanes.

5.3.2.2 Methodology for Projecting Ridership for Mode Combinations

When the individual modes were combined, the competition between modes serving similar markets was considered to avoid double counting and over estimating total ridership. Each service/market area was assigned to a specific station for a particular mode based on the mode which provided the best service to the area (based on the total impedance which is described in Chapter 3).

In general, a service or market area was assigned to the mode option which had the least impedance. If the impedance difference was substantial, 100 percent of the transit ridership was assigned to the first option. If the difference between the impedances for two mode options was minor, then the ridership was apportioned to the two options based on the terminal each option serves in Boston (South Station or North Station). Because the majority of employment in downtown Boston is located

closer to South Station than to North Station, the majority of trips were assigned to the option serving South Station and the remainder was assigned to the option serving North Station.

A bus subsidy was included in each combination that contained both a rail line and a bus option. This was done to make the bus options competitive with the rail options when they were provided together. In mode combinations without a rail option, no bus subsidy was included. For projections of bus ridership for combinations with an HOV lane, it was assumed that the bus would travel in the HOV lane and benefit from the travel time savings the HOV lane would provide.

For the analysis of combinations with an HOV mode option, it was assumed that the HOV lane would continue to I-95 (Route 128) in Massachusetts and that it was in addition to whatever number of general purpose lanes were included in the analysis. The total number of lanes, including the HOV lane, was never more than four in each direction. For mode combinations with an HOV lane, the highway configuration was one of the following:

- Two general purpose lanes and one HOV lane north of Exit 1 and three general purpose lanes and one HOV lane south of Exit 1 in New Hampshire. The segment between Exit 1 and the state line already three general purpose lanes and a general purpose lane would not be eliminated to provide the HOV lane.

- Three general purpose lanes and one HOV lane between I-293 and the state line.

The HOV volume on each link was increased by adding 20 percent of the base no-build HOV volume to account for non-work HOV trips. No overlap of HOV utilization with bus and rail ridership was assumed.

5.3.2.3 Ridership Projections for Mode Combinations

Table 5.3-2 summarizes the results of the ridership projections for the 14 mode combinations. It presents total transit ridership broken down for each individual service. West Rail boardings at Merrimack are not included in the table because they represent riders diverted from Route 3 rather than I-93. The total transit ridership is then converted to person trips diverted from I-93 by subtracting 853 to account for future ridership on the existing bus service that could be expected under the no-build condition.

Mode Combinations 3 and 13 have the largest projected transit ridership with 3,365 daily southbound trips. Both combinations include Enhanced Rail with two general purpose lanes. Although Combination 13 also includes East Rail, the ridership projections are the same for each combination because the Enhanced and East rails both serve the same markets.

The next largest ridership projections are for Mode Combinations 5 and 14 with just under 3,000 daily southbound trips each. Both of these combinations include Enhanced and Expanded bus service, an HOV lane, and a bus subsidy. Mode Combination 5 also includes West Rail and two general purpose lanes on I-93 while Combination 14 includes Enhanced Rail and three general purpose lanes on I-93. The most effective transit combinations involve Enhanced Rail or both Enhanced and Expanded Bus service with an HOV lane and bus subsidy.

To determine the impact of the transit modes on roadway conditions, the projected ridership for these modes was diverted from the traffic volumes on the appropriate highway segments. Once the reduction in person trips was determined, it was converted to a reduction in vehicle trips by dividing by 1.11, which is the average auto occupancy rate for the area from the 1990 journey-to-work (JTW) census data. The result is the number of daily vehicles reduced because of the new transit services.

The table also includes the daily reduction in the number of vehicles on I-93 because of diversions from single occupant vehicles to HOVs resulting from the provision of an HOV lane. The number of HOVs created was subtracted from the number of SOVs eliminated to calculate the net reductions in vehicles. The largest reduction in vehicles resulting from the HOV lane is 480 daily southbound vehicles. This occurs when there are only two general purpose lanes on I-93. With three general purpose lanes the number of vehicles diverted is reduced to about 290.

Daily and peak period reductions in vehicles from I-93 southbound between Exit 1 and the Massachusetts state line are presented in Table 5.3-3. The largest total reduction in daily vehicles, because of diversions to transit and HOV modes, is projected for Mode Combination 5 with a reduction of almost 2,400 daily southbound vehicles. Combinations 3 and 13 result in a reduction of almost 2,300 vehicles. These reductions are compared with the total daily directional traffic volume on I-93 without any alternative mode options. The nearly 2,400 vehicle reduction with Combination 5 is 3.3 percent of the total daily directional volume of 71,100.

To estimate peak period reductions and analyze the impacts on traffic resulting from diversions to bus, rail, and HOV lanes, three-hour peak period reductions were calculated from the daily reductions. Existing congestion on I-93 extends over a three hour period in both the morning and evening. Peak direction volumes in each of the three hours of the peak periods are similar and approach the capacity of the roadway. The additional hours of peak volume beyond the typical single highest volume hour are referred to as the “shoulder hours”. Congestion spills into the shoulder hours as demand in the peak hour grows beyond the capacity of the roadway. Correspondingly, when reductions in demand occur in the peak period, the impact will first be felt in the shoulder hours and then eventually in the peak hour as the reductions become larger.

The peak period reductions were estimated separately for transit and HOV modes. The daily transit reduction was converted to a three-hour peak period reduction assuming that 82 percent of daily one-way volume occurs in the peak period. The 82 percent was estimated from existing MBTA commuter rail ridership data. The daily HOV vehicle reduction was used directly for the three-hour peak period reduction because the HOV lane would probably be restricted to HOVs only in peak periods. Further, the lack of congestion in general purpose lanes in non-peak periods would remove any advantage for using an HOV facility during non-peak times.

Table 5.3-2
2020 Daily Southbound Ridership and Vehicle Reductions on I-93[1] Resulting from Bus, Rail and HOV Combinations

Mode Combination	Transit Ridership							Diversions to Transit		Diversions to HOV		Total Reduction in Vehicles	Daily Vehicle Volume
	Existing Bus	Expanded Bus	Enhanced Bus	Enhanced Rail	West Rail[2]	East Rail	Total Transit	Person Trips[3]	Vehicles[4]	Person Trips	Vehicles[5]		
1	575				417		992	139	125	0	0	125	67,550
2	368					907	1,275	422	380	0	0	380	67,550
3	368			2,997			3,365	2,512	2,263	0	0	2,263	67,550
4		1,833	854				2,687	1,834	1,652	862	477	2,129	71,100
5		1,899	941		137		2,977	2,124	1,914	862	477	2,391	71,100
6		1,258	409				1,667	814	733	0	0	733	71,100
7		1,721	551				2,272	1,419	1,278	520	287	1,565	71,800
8		1,238	449		273		1,960	1,107	997	0	0	997	71,100
9		1,806	615		113		2,534	1,681	1,514	520	287	1,801	71,800
10		1,248	351				1,599	746	672	0	0	672	71,800
11			1,342			815	2,157	1,304	1,175	862	477	1,652	71,100
12			1,075			521	1,596	743	669	520	287	956	71,800
13	368			2,922		75	3,365	2,512	2,263	0	0	2,263	67,550
14		1,889	217	850			2,956	2,103	1,895	520	287	2,182	71,800

1 Ridership and vehicle reductions are for the segment of I-93 between Exit 1 and the Massachusetts/New Hampshire state line
2 The West Rail ridership excludes boardings (160) at Merrimack since these do not affect I-93 traffic
3 Excludes future ridership on existing bus service (853)
4 Person trips divided by 1.11 average vehicle occupancy
5 Vehicle reductions were calculated by dividing the number of new HOV person trips by 2.24 (the 2+ auto occupancy rate from the 1990 Journey-to-Work data) to obtain the number of new HOV vehicles. The resulting number of new HOV vehicles was subtracted from the number of single occupancy vehicles (SOVs) eliminated from the roadway (which is equivalent to the new HOV person trips) to obtain the net reduction in the number of vehicles on the roadway.

Table 5.3-3
2020 Daily and Peak Period Southbound Vehicle Reductions on I-93[1] Resulting from Bus, Rail and HOV Combinations

Mode Combination	Daily Vehicle Reduction[2]			Daily No-Build Vehicle Volume[3]	Percent Reduction in Daily Vehicles	Peak Period[4] Vehicle Reduction			Peak Period No-Build Volume[5]	Percent Reduction in Peak Period Vehicles
	Transit	HOV	Total			Transit	HOV	Total		
1	125	0	125	67,550	0.2%	103	0	103	21,716	0.5%
2	380	0	380	67,550	0.6%	312	0	312	21,716	1.4%
3	2,263	0	2,263	67,550	3.4%	1,856	0	1,856	21,716	8.5%
4	1,652	477	2,129	71,100	3.0%	1,356	477	1,833	22,857	8.0%
5	1,914	477	2,391	71,100	3.3%	1,568	477	2,045	22,857	8.9%
6	733	0	733	71,100	1.0%	601	0	601	22,857	2.6%
7	1,278	287	1,565	71,800	2.2%	1048	287	1,335	23,082	5.8%
8	997	0	997	71,100	1.4%	818	0	818	22,857	3.6%
9	1,514	287	1,801	71,800	2.5%	1,242	287	1,529	23,082	6.6%
10	672	0	672	71,800	0.9%	551	0	551	23,082	2.4%
11	1,175	477	1,652	71,100	2.3%	963	477	1,440	22,857	6.3%
12	669	287	956	71,800	1.3%	549	287	836	23,082	3.6%
13	2,263	0	2,263	67,550	3.4%	1,856	0	1,856	21,716	8.5%
14	1,895	287	2,182	71,800	3.0%	1,554	287	1,841	23,082	8.0%

1. Ridership and vehicle reductions are for the segment of I-93 between Exit 1 and the Massachusetts/New Hampshire state line
2. Southbound direction. A similar reduction is anticipated for the northbound direction.
3. Daily No-Build traffic volume varies based on the total number of general purpose and HOV lanes provided on I-93.
4. Three-hour morning peak period. Similar results are expected for the northbound direction in the three hour evening peak period.
5. Design hour directional volume.

Peak period vehicle reductions range from about 100 vehicles for Mode Combination 1 to almost 2,050 vehicles for Mode Combination 5. The reduction for Combination 5 represents a 9 percent decrease in the design hour directional volume. Several other combinations produce reductions of 8 percent or more, including Combinations 3, 4, 13, and 14.

Table 5.3-4 shows the percentage of the total market for each combination, which is shifted to transit for Boston bound travelers, and for travelers to I-93 employment centers. Mode Combinations 3 and 13 capture 44 percent of all Boston bound trips and 11 percent of trips to I-93 employment centers in Massachusetts. Combinations 4, 5, 9, and 14 capture 50 percent or more of Boston bound travelers on transit. They all include Enhanced and Expanded bus service with an HOV lane. All four of these combinations except Combination 4 also include a bus subsidy.

Table 5.3-4
Transit Capture Rates

	Boston Travelers			I-93 Travelers		
Mode Combination	Total Market	Total Ridership	Transit Capture Rate	Total Market	Total Ridership	Transit Capture Rate
1	2,680	1,152	43%	0	0	0
2	3,477	1,276	37%	0	0	0
3	3,700	1,626	44%	15,501	1,738	11%
4	3,700	1,833	50%	11,284	854	8%
5	4,037	2,196	54%	11,284	941	8%
6	3,700	1,258	34%	11,284	409	4%
7	3,700	1,721	47%	11,284	551	5%
8	4,037	1,671	41%	11,284	449	4%
9	4,037	2,079	52%	11,284	615	5%
10	3,700	1,248	34%	11,284	351	3%
11	3,700	1,216	33%	11,284	941	8%
12	3,700	981	27%	11,284	615	5%
13	3,700	1,626	44%	15,501	1,738	11%
14	3,700	2,060	56%	15,501	896	6%

5.3.3 Highway Level of Service Analysis

The purpose of this section is to summarize the results of the traffic operations analysis for each of the mode combinations that were presented in the previous section. As described previously the primary result of the operational analyses is the assignment of level of service. Six levels of service (LOS) are defined ranging in letter designation from LOS A to LOS F, with LOS A representing the best operating condition and LOS F representing the worst. LOS C describes a stable flow condition and is considered desirable for peak or design hour traffic flow. LOS D is generally considered acceptable where the cost and impacts of making improvements to provide LOS C are deemed unjustifiable. Level of Service E is capacity. In general the capacity of a freeway type lane is reached when the volume of traffic approaches approximately 2,200 vph. Volumes above that cause the time of congestion to lengthen into the hour before and after the peak hour congestion. The level of service analyses have been conducted for each segment of the I-93 corridor for the 2020 design hour volumes.

The evaluation of the various alternative modes of transportation, as presented in the previous section, provides ridership estimates for alternative modes such as rail and bus, and usage estimates for an HOV lane. Use of rail, bus and HOV lanes by commuters would result in fewer vehicle trips on the I-93 corridor and, consequently could reduce the number of lanes needed to maintain an acceptable level of service during the design hour.

The subsequent evaluation of traffic operations, taking into account the possible reductions in vehicle trips due to the availability of alternative modes of travel, shows that the availability of alternative modes would not reduce the volume of traffic on I-93 to a level where an acceptable level of service could be maintained with fewer travel lanes. Specifically, the various alternative modes of travel would result in little or no reduction in travel on I-93 during the design hour.

These various alternative modes of travel result in little or no reduction in the volume of traffic during the Design Hour because the level of congestion along the corridor currently extends well beyond a one hour period and would be further exacerbated in the 2020 design year. Currently, commuters routinely experience substantial delays that extend over a three hour period. Therefore, the reductions in traffic that result from the various alternative modes of transportation actually occur at the outside of the commuter period rather than during the design hour. In other words, the use of other modes of transportation would serve to reduce the number of hours of congestion, but not the level of congestion within the design hour.

Tables 5.3-5 through 5.3-10 summarize the 2020 Directional Design Hour Volumes (DDHV) and Levels of Service for each segment of I-93 between the Massachusetts state line and I-293. The tables include the levels of service for both the directional design hour and the hour immediately before or after the directional design hour

(i.e., shoulder hour). In doing so, the merits of any particular mode combination for a particular segment can be better evaluated. For example, if the level of service remains the same both in the directional design hour and the shoulder hour, then the mode combination has a more marginal effect on addressing the needs of the highway. If the shoulder hour has a better level of service, then the mode combination shows more potential for addressing the highway needs of the particular segment.

A summary of the level of service analyses for all the segments of the corridor is presented in Table 5.3-11. As shown in the table, none of the mode combinations meet the established criteria of providing at least a LOS D operation over all segments for the 2020 design hour. However, Mode Combination 10, which is the only combination that provides four general purpose lanes, comes the closest to meeting the criteria as LOS D or better is provided along each segment of the corridor with the exception of the segment south of Exit 1. The four-lane section south of Exit 1 would operate at LOS E. This result is consistent with the previously stated finding that 5 lanes in each direction would be needed south of Exit 1 to maintain a LOS D.

All other mode combinations show either a LOS E or a LOS F operation for the 2020 Design Hour along the segments south of Exit 3. In fact, only Mode Combinations 7, 9, and 14, which each provide three general purpose lanes plus an HOV lane in various combinations with bus service, the west rail, and the enhanced rail, were able to obtain a LOS D operation between Exits 1 and 3 for the hour prior to and following the design hour.

Table 5.3-5
2020 Directional Design Hour Volumes (DDHV) and Level of Service for I-93 Between Exit 1 and the Massachusetts State Line Resulting from Bus, Rail and HOV Lane Improvements

	Number of Lanes[1]				Peak Period Reductions for Transit/HOV			DDHV				Hour Before and After DDHV			
Mode Combination	General Purpose	HOV	Total	DDHV Before Reduction	Peak Period Reductions[2]	Design Hour Reduction	DDHV After Reduction	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service
1	3	0	3	7,620	103	0	7,620	0	7,620	2,200	F	0	7,507	2,200	F
2	3	0	3	7,620	312	0	7,620	0	7,620	2,200	F	0	7,402	2,200	F
3	3	0	3	7,620	1,856	73	7,547	0	7,547	2,200	F	0	6,630	2,200	F
4	3	1	4	8,020	1,832	31	7,989	897	7,092	2,200	F	571	6,193	2,064	F
5	3	1	4	8,020	2,045	112	7,909	897	7,012	2,200	F	571	6,087	2,029	F
6	3	0	3	8,020	601	0	8,020	0	8,020	2,200	F	0	7,828	2,200	F
7	3	1	4	8,099	1,335	0	8,099	830	7,269	2,200	F	528	6,631	2,200	F
8	3	0	3	8,020	818	0	8,020	0	8,020	2,200	F	0	7,720	2,200	F
9	3	1	4	8,099	1,529	0	8,099	830	7,269	2,200	F	528	6,534	2,178	F
10	4	0	4	8,099	551	0	8,099	0	8,099	2,025	E	0	7,216	1,804	E
11	3	1	4	8,020	1,440	0	8,020	897	7,123	2,200	F	571	6,389	2,130	F
12	3	1	4	8,020	836	0	8,099	830	7,269	2,200	F	528	6,880	2,200	F
13	3	0	3	7,620	1,856	73	7,547	0	7,547	2,200	F	0	6,630	2,200	F
14	3	1	4	8,099	1,841	27	8,072	830	7,242	2,200	F	528	6,378	2,126	F

[1] Roadway cross section in each direction north of Exit 1 (currently two general purpose lanes). South of Exit 1, the existing cross section consists of three general purpose lanes in each direction.

[2] Sum of peak period reductions for bus and rail and reductions for HOV lane use from Table 5.3-3.

Table 5.3-6
2020 Directional Design Hour Volumes (DDHV) and Level of Service for I-93 Between Exit 2 and Exit 1 Resulting from Bus, Rail and HOV Lane Improvements

	Number of Lanes[1]				Peak Period Reductions for Transit/HOV			DDHV				Hour Before and After DDHV			
Mode Combination	General Purpose	HOV	Total	DDHV Before Reduction	Peak Period Reductions[2]	Design Hour Reduction	DDHV After Reduction	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service
1	2	0	2	5,843	103	0	5,843	0	5,843	2,200	F	0	6,075	2,200	F
2	2	0	2	5,843	282	0	5,843	0	5,843	2,200	F	0	5,985	2,200	F
3	2	0	2	5,843	1,856	220	5,623	0	5,623	2,200	F	0	5,198	2,200	F
4	2	1	3	6,447	1,775	140	6,307	747	5,560	2,200	F	475	5,250	2,200	F
5	2	1	3	6,447	1,988	220	6,226	747	5,479	2,200	F	475	5,143	2,200	F
6	3	0	3	6,447	601	0	6,447	0	6,447	2,149	F	0	5,662	1,887	E
7	3	1	4	6,571	1,279	0	6,571	680	5,891	1,964	E	433	5,006	1,669	D
8	3	0	3	6,447	818	0	6,447	0	6,447	2,149	F	0	5,554	1,851	E
9	3	1	4	6,571	1,472	14	6,557	680	5,877	1,959	E	433	4,916	1,639	D
10	4	0	4	6,571	551	0	6,571	0	6,571	1,643	D	0	5,802	1,451	D
11	2	1	3	6,447	1,354	0	6,447	747	5,700	2,200	F	475	5,460	2,200	F
12	3	1	4	6,571	750	0	6,571	680	5,891	1,964	E	433	5,270	1,757	E
13	2	0	2	5,843	1,856	220	5,623	0	5,623	2,200	F	0	5,198	2,200	F
14	3	1	4	6,571	1,784	133	6,438	680	5,758	1,919	E	433	4,820	1,607	D

[1] Roadway cross section in each direction north of Exit 1 (currently two general purpose lanes). South of Exit 1, the existing cross section consists of three general purpose lanes in each direction.

[2] Sum of peak period reductions for bus and rail and reductions for HOV lane use from Table 5.3-3.

Table 5.3-7
2020 Directional Design Hour Volumes (DDHV) and Level of Service for I-93 Between Exit 3 and Exit 2 Resulting from Bus, Rail and HOV Lane Improvements

	Number of Lanes[1]				Peak Period Reductions for Transit/HOV			DDHV				Hour Before and After DDHV			
Mode Combination	General Purpose	HOV	Total	DDHV Before Reduction	Peak Period Reductions[2]	Design Hour Reduction	DDHV After Reduction	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service
1	2	0	2	5,527	103	0	5,527	0	5,527	2,200	F	0	5,625	2,200	F
2	2	0	2	5,527	197	0	5,527	0	5,527	2,200	F	0	5,578	2,200	F
3	2	0	2	5,527	1,487	106	5,421	0	5,421	2,200	F	0	4,933	2,200	F
4	2	1	3	6,040	1,422	39	6,001	698	5,304	2,200	F	444	4,904	2,200	F
5	2	1	3	6,040	1,607	109	5,931	698	5,234	2,200	F	444	4,811	2,200	F
6	3	0	3	6,040	363	0	6,040	0	6,040	2,013	F	0	5,406	1,802	E
7	3	1	4	6,142	932	0	6,142	631	5,511	1,837	E	401	4,814	1,605	D
8	3	0	3	6,040	554	0	6,040	0	6,040	2,013	F	0	5,310	1,770	E
9	3	1	4	6,142	1,097	0	6,142	631	5,511	1,837	E	401	4,732	1,577	D
10	4	0	4	6,142	315	0	6,142	0	6,142	1,535	D	0	5,524	1,381	D
11	2	1	3	6,040	1,259	0	6,040	698	5,343	2,200	F	444	4,985	2,200	F
12	3	1	4	6,142	660	0	6,142	631	5,511	1,837	E	401	4,950	1,650	E
13	2	0	2	5,527	1,487	106	5,421	0	5,421	2,200	F	0	4,933	2,200	F
14	3	1	4	6,142	1,307	0	6,142	631	5,511	1,837	E	401	4,626	1,542	D

[1] Roadway cross section in each direction north of Exit 1 (currently two general purpose lanes). South of Exit 1, the existing cross section consists of three general purpose lanes in each direction.

[2] Sum of peak period reductions for bus and rail and reductions for HOV lane use from Table 5.3-3.

Table 5.3-8
2020 Directional Design Hour Volumes (DDHV) and Level of Service for I-93 Between Exit 4 and Exit 3 Resulting from Bus, Rail and HOV Lane Improvements

	Number of Lanes[1]				Peak Period Reductions for Transit/HOV			DDHV				Hour Before and After DDHV			
Mode Combination	General Purpose	HOV	Total	DDHV Before Reduction	Peak Period Reductions[2]	Design Hour Reduction	DDHV After Reduction	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service
1	2	0	2	4,117	103	0	4,117	0	4,117	2,059	F	0	3,757	1,879	E
2	2	0	2	4,117	75	0	4,117	0	4,117	2,059	F	0	3,771	1,885	E
3	2	0	2	4,117	1,286	147	3,970	0	3,970	1,985	F	0	3,239	1,619	D
4	2	1	3	4,281	1,139	77	4,203	631	3,572	1,786	E	402	3,027	1,514	D
5	2	1	3	4,281	1,308	142	4,139	631	3,508	1,754	E	402	2,975	1,488	D
6	3	0	3	4,281	223	0	4,281	0	4,281	1,427	D	0	3,848	1,283	C
7	3	1	4	4,320	705	0	4,320	570	3,750	1,250	C	363	3,281	1,094	C
8	3	0	3	4,281	400	0	4,281	0	4,281	1,427	D	0	3,760	1,253	C
9	3	1	4	4,320	854	0	4,320	570	3,750	1,250	C	363	3,206	1,069	C
10	4	0	4	4,320	182	0	4,320	0	4,320	1,080	C	0	3,905	976	C
11	2	1	3	4,281	1,004	26	4,254	631	3,623	1,812	E	402	3,069	1,535	D
12	3	1	4	4,320	507	0	4,320	570	3,750	1,250	C	363	3,380	1,127	C
13	2	0	2	4,117	1,286	147	3,970	0	3,970	1,985	F	0	3,239	1,619	D
14	3	1	4	4,320	1,068	47	4,273	570	3,703	1,234	C	363	3,123	1,041	C

[1] Roadway cross section in each direction north of Exit 1 (currently two general purpose lanes). South of Exit 1, the existing cross section consists of three general purpose lanes in each direction.

[2] Sum of peak period reductions for bus and rail and reductions for HOV lane use from Table 5.3-3.

Table 5.3-9
2020 Directional Design Hour Volumes (DDHV) and Level of Service for I-93 Between Exit 5 and Exit 4 Resulting from Bus, Rail and HOV Lane Improvements

	Number of Lanes[1]				Peak Period Reductions for Transit/HOV			DDHV				Hour Before and After DDHV			
Mode Combination	General Purpose	HOV	Total	DDHV Before Reduction	Peak Period Reductions[2]	Design Hour Reduction	DDHV After Reduction	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service
1	2	0	2	4,580	117	0	4,580	0	4,580	2,200	F	0	4,268	2,134	F
2	2	0	2	4,580	121	0	4,580	0	4,580	2,200	F	0	4,265	2,133	F
3	2	0	2	4,580	849	0	4,580	0	4,580	2,200	F	0	3,902	1,951	E
4	2	1	3	4,760	850	0	4,760	451	4,309	2,155	F	287	3,691	1,846	E
5	2	1	3	4,760	963	0	4,760	451	4,309	2,155	F	287	3,635	1,817	E
6	3	0	3	4,760	295	0	4,760	0	4,760	1,587	D	0	4,255	1,418	D
7	3	1	4	4,805	588	0	4,805	409	4,396	1,465	D	261	3,890	1,297	C
8	3	0	3	4,760	428	0	4,760	0	4,760	1,587	D	0	4,189	1,396	D
9	3	1	4	4,805	684	0	4,805	409	4,396	1,465	D	261	3,842	1,281	C
10	4	0	4	4,805	272	0	4,805	0	4,805	1,201	C	0	4,309	1,077	C
11	2	1	3	4,760	710	0	4,760	451	4,309	2,155	F	287	3,761	1,881	E
12	3	1	4	4,805	404	0	4,805	409	4,396	1,465	D	261	3,982	1,327	C
13	2	0	2	4,580	850	0	4,580	0	4,580	2,200	F	0	3,901	1,951	E
14	3	1	4	4,805	796	0	4,805	409	4,396	1,465	D	261	3,786	1,262	C

[1] Roadway cross section in each direction north of Exit 1 (currently two general purpose lanes). South of Exit 1, the existing cross section consists of three general purpose lanes in each direction.

[2] Sum of peak period reductions for bus and rail and reductions for HOV lane use from Table 5.3-3.

Table 5.3-10
2020 Directional Design Hour Volumes (DDHV) and Level of Service for I-93 Between I-293 and Exit 5 Resulting from Bus, Rail and HOV Lane Improvements

	Number of Lanes[1]				Peak Period Reductions for Transit/HOV			DDHV				Hour Before and After DDHV			
Mode Combination	General Purpose	HOV	Total	DDHV Before Reduction	Peak Period Reductions[2]	Design Hour Reduction	DDHV After Reduction	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service	HOV Lane Volume	General Lane Volume (total)	General Lane Volume (per lane)	Level Of Service
1	2	0	2	4,755	98	0	4,755	0	4,755	2,200	F	0	4,526	2,200	F
2	2	0	2	4,755	78	0	4,755	0	4,755	2,200	F	0	4,536	2,200	F
3	2	0	2	4,755	354	0	4,755	0	4,755	2,200	F	0	4,398	2,199	F
4	2	1	3	4,946	340	0	4,946	276	4,670	2,200	F	176	4,365	2,182	F
5	2	1	3	4,946	396	0	4,946	276	4,670	2,200	F	176	4,337	2,168	F
6	3	0	3	4,946	49	0	4,946	0	4,946	1,649	D	0	4,551	1,517	D
7	3	1	4	5,014	193	0	5,014	253	4,761	1,587	D	161	4,380	1,460	D
8	3	0	3	4,946	139	0	4,946	0	4,946	1,649	D	0	4,506	1,502	D
9	3	1	4	5,014	235	0	5,014	253	4,761	1,587	D	161	4,359	1,453	D
10	4	0	4	5,014	36	0	5,014	0	5,014	1,253	C	0	4,620	1,155	C
11	2	1	3	4,946	368	0	4,946	276	4,670	2,200	F	176	4,351	2,175	F
12	3	1	4	5,014	200	0	5,014	253	4,761	1,587	D	161	4,377	1,459	D
13	2	0	2	4,755	354	0	4,755	0	4,755	2,200	F	0	4,398	2,199	F
14	3	1	4	5,014	268	0	5,014	253	4,761	1,587	D	161	4,342	1,447	D

[1] Roadway cross section in each direction north of Exit 1 (currently two general purpose lanes). South of Exit 1, the existing cross section consists of three general purpose lanes in each direction.

[2] Sum of peak period reductions for bus and rail and reductions for HOV lane use from Table 5.3-3.

Table 5.3-11
2020 Directional Design Hour Volumes (DDHV) and Shoulder Hour Level of Service Summary for I-93 Between I-293 and the Massachusetts State Line Resulting from Bus, Rail and HOV Lane Improvements

	South of Exit 1		Exit 1 to Exit 2		Exit 2 to Exit 3		Exit 3 to Exit 4		Exit 4 to Exit 5		North of Exit 5	
Mode Combination	DDHV[1] LOS[2]	Shoulder Hour[3] LOS	DDHV LOS	Shoulder Hour LOS	DDHV LOS	Shoulder Hour LOS	DDHV LOS	Shoulder Hour LOS	DDHV LOS	Shoulder Hour LOS	DDHV LOS	Shoulder Hour LOS
1 (No-Build w/West Rail)	F	F	F	F	F	F	F	E	F	F	F	F
2 (No-Build w/Enhanced Rail)	F	F	F	F	F	F	F	E	F	F	F	F
3 (No-Build w/Rail)	F	F	F	F	F	F	F	D	F	E	F	F
4 (No-Build w/HOV, Bus)	F	F	F	F	F	F	E	D	F	E	F	F
5 (No-Build w/HOV, Bus, West Rail)	F	F	F	F	F	F	E	D	F	E	F	F
6 (3 Lanes w/Bus)	F	F	F	E	F	E	D	C	D	D	D	D
7 (3 Lanes w/HOV, Bus)	F	F	E	D	E	D	C	C	D	C	D	D
8 (3 Lanes w/Bus, West Rail)	F	F	F	E	F	E	D	C	D	D	D	D
9 (3 Lanes w/HOV, Bus, West Rail)	F	F	E	D	E	D	C	C	D	C	D	D
10 (4 Lanes w/Bus)	E	E	D	D	D	D	C	C	C	C	C	C
11 (2 Lanes w/HOV, Bus, East Rail)	F	F	F	F	F	F	E	D	F	E	F	F
12 (3 Lanes w/HOV, Bus, East Rail)	F	F	E	E	E	E	C	C	D	C	D	D
13 (2 Lanes w/HOV, Bus, East Rail)	F	F	F	F	F	F	F	D	F	E	F	F
14 (3 Lanes w/HOV, Bus, Enhanced Rail)	F	F	E	D	E	D	C	C	D	C	D	D

[1] DDHV – Directional Design Hour Volume
[2] LOS – Level of Service (see attached sheet for definition)
[3] Shoulder Hour – The Hour before and after the Design Hour

5.3.4 Considerations and Implications

5.3.4.1 Impacts on Traffic Level of Service

The analysis of levels of service on I-93 with various combinations of rail, bus, and HOV options indicates that in 2020 I-93 would continue to operate at deficient levels of service and would require additional travel lanes to operate at acceptable levels of service. None of the alternative combinations of rail, bus, and HOV options reduces the number of additional travel lanes needed to provide acceptable operating levels of service.

The mode combinations tested were developed to maximize rail, bus, and HOV ridership and the resulting diversion of traffic from I-93. Some of the combinations included no widening of I-93. These combinations were developed because the ridership projections are based, in part, on the relative travel times of the various modes. Ridership on rail, bus, and the HOV lane is maximized when travel times on the highway are greatest. The greatest travel time on I-93 would occur without any roadway widening. Widening the roadway will decrease delay and reduce the number of drivers diverted to rail, bus, or HOV options. The combinations with the greatest diversion did not result in a reduction in the number of additional lanes needed for I-93 in 2020.

5.3.4.2 Rail Ridership

Enhanced Rail Corridor

The Enhanced Rail Corridor provides service for Boston bound travelers as well as for travelers to major employment centers in northern Massachusetts along I-93. Based on the initial analysis of all the rail options (assuming four travel lanes in each direction on I-93), Enhanced Rail generates the largest number of daily boardings to Boston (1,160). It also generates an additional 650 daily boardings to northern Massachusetts. In the analysis of mode combinations, the Enhanced Rail generated almost 3,000 daily boardings with only two lanes in each direction on I-93. About 1,260 of these boardings are for trips to downtown Boston.

The major disadvantage of the Enhanced Rail corridor is that it depends on the continuation of the corridor in Massachusetts to the planned Woburn Transportation Center. A feasibility study of the I-93 corridor in Methuen and Andover in northern Massachusetts is just beginning and consideration of an I-93 rail corridor is a part of that study. Conclusions from that study are expected in the fall of 2001.

East and I-93 Basic Corridors

When analyzed individually, the East and I-93 Basic rail corridors generated the second highest levels of increased daily boardings (half the level of the Enhanced Rail Corridor). They generated roughly the same level of ridership with 957 and 900 boardings, respectively. Although these ridership levels are lower than the Boston bound riders on the Enhanced Rail Corridor, neither corridor is as dependent on an extensive infrastructure investment in Massachusetts as is the Enhanced Corridor.

West Corridor

When analyzed individually, the West Rail Corridor generates the smallest increase in rail boardings (428) of the four rail alternatives. Further, the portion of the West Corridor ridership generated by the Merrimack Station (160) is not expected to divert traffic from I-93. Therefore, in terms of its impact on I-93 traffic, the West Rail Corridor appears to be the least effective rail option.

5.3.4.3 HOV Lanes

Recommendations relative to incorporating HOV lanes in the improvements for I-93 are influenced by the following factors:

Projected Volume

One criteria for judging the success of an HOV facility is the volume of vehicles and passengers that it would carry. National Cooperative Highway Research Program (NCHRP) Report 414, HOV Systems Manual, recommends a minimum operating threshold of 400 to 800 vehicles per hour per lane for freeway HOV lanes. The establishment of a minimum operating threshold is designed to ensure that the facility does not appear to be underutilized to users of the general purpose lanes. The goal is to avoid what is referred to as "empty lane syndrome." Since all the HOV analyses have been based on 2+ HOVs, the 800 vehicle minimum operating threshold appears to be appropriate for the I-93 corridor.

Projected peak hour HOV lane volumes with three general purpose lanes in each direction the entire length of the corridor would exceed the 800 vehicle minimum operating threshold only on the segment south of Exit 1 (with a projected volume of 830). With only two general purpose lanes throughout the corridor (except south of Exit 1 where there are currently three lanes), the segment south of Exit 2 is projected to have a peak hour volume of approximately 750, just below the 800 vehicle threshold. With either 2 or 3 general purpose lanes, the smallest minimum operating threshold (400) would not be exceeded north of Exit 5 and would barely be met north of Exit 4. As a result, projected hourly HOV volumes do not meet a minimum operating threshold that would be appropriate for I-93 between Salem and Manchester.

HOV Lane in Massachusetts

The volumes projected through the ridership study and mode combinations analysis are based on the assumption that the HOV facility is continued in Massachusetts between the state line and I-95 (Route 128). The projected HOV volume south of Exit 1 was about 100 vehicles lower if there was no HOV facility in Massachusetts compared to if there was such a facility. Based on that analysis, if there was no Massachusetts facility, the 800 vehicle minimum operating threshold would not be met on any segment of I-93 and the 400 vehicle threshold would be not be met for the segments north of Exit 4.

The feasibility study of I-93 in Methuen and Andover, Massachusetts will consider an HOV lane as an alternative. The study is expected to be completed in late September 2001.

Impact on I-93 Traffic Volumes

The provision of an HOV lane is designed to encourage the formation of carpools and reduce the number of vehicles on the roadway. Based on the travel time savings expected with an HOV lane that continues into Massachusetts to I-95 and assuming there are three general purpose lanes in addition to the HOV lane, a reduction of approximately 125 vehicles in the peak hour is expected south of Exit 1. This represents about 1.6 percent of the projected peak hour volume of 7,650 vehicles. Similar or smaller percentage reductions are expected on segments north of Exit 1. These reductions are not large enough to have a discernible effect on traffic congestion in the general purpose lanes.

5.3.4.4 Bus Ridership

The major conclusion from the initial analysis of the Expanded Bus service was that an HOV lane in both Massachusetts and New Hampshire substantially increased bus ridership. An HOV lane in New Hampshire-only had little effect on ridership. Ridership on the Expanded Bus with four lanes on I-93 rose from almost 1,300 with no HOV lane or with a New Hampshire-only HOV lane to almost 1,950 with an HOV lane in both New Hampshire and Massachusetts.

The analysis of individual options also included consideration of a bus fare subsidy comparable to the fare subsidy that would be provided to rail users under the current MBTA fare structure. With a Massachusetts HOV lane, the subsidy increased daily bus boardings by 270 to 2,220 and without the Massachusetts HOV lane, it increased daily boardings by 250 to 1,550.

The largest bus ridership projection is 2,840 daily boardings with Mode Combination 5. Mode Combination 5 includes an HOV lane, bus subsidy, Expanded and Enhanced bus service, and the West Rail Corridor. The projected ridership is

somewhat less than the 3,000 daily boardings projected for the Enhanced Rail (Mode Combination 3).

An HOV lane appears to have the greatest impact on bus ridership. Mode Combinations 6 and 7 are the same except for an HOV lane (both include three travel lanes, no subsidy, and Expanded and Enhanced bus service). Ridership is about 1,670 daily boardings without the HOV lane and about 2,270 with the lane, for a difference of 600 boardings daily. A similar observation can be made with Mode Combinations 8 and 9 for which the only difference is also an HOV lane. Daily boardings without the HOV lane are 1,690 and about 2,420 with the lane, for a difference of about 730.

5.3.4.5 Related Issues

In addition to the conclusions presented above, several related issues need to be considered:

- The ridership projections for the most part are based on commuter traffic expected during peak commuter hours. The projections do not take into account weekend or holiday tourist or recreational traffic. The various modes analyzed in the ridership projections would not generally serve tourist or recreational traffic very well.

- The ridership projections do not address or account for safety deficiencies associated with the existing highway. They also do not address how safety may be compromised by the high volumes of traffic utilizing a corridor with insufficient roadway capacity.

- The projections of ridership for various bus options does not include an estimate of the number of buses needed to carry the projected ridership. Of particular concern is the capacity of existing bus docking space at the South Station bus terminal. Currently, limited capacity is available and there are no improvements programmed. Also, there are questions about the practicality of operating the number of buses that would be needed to serve the projected ridership.

5.3.5 Summary Conclusions

The following summarizes conclusions reached regarding the transit and HOV options based on the ridership projections and highway level of service analysis presented above.

- The various transit and HOV options, either alone or in combination, do not reduce the number of additional travel lanes required to provide acceptable levels of service on I-93.

- The most effective transit options in terms of the net diversion of vehicles from I-93 are the Enhanced Rail Corridor or the provision of an HOV lane with Expanded and Enhanced bus service. The Enhanced Rail Corridor generates the highest level of ridership of all the transit options. The combination of Enhanced and Expanded bus service with an HOV lane generates almost as much ridership as the Enhanced Rail Corridor. The net diversion for each of these alternatives is approximately the same.

- The Enhanced Rail Corridor requires extensive infrastructure improvements in Massachusetts along the I-93 corridor to provide service to major employment centers and the Woburn Transportation Center (a rail option along the I-93 corridor in Massachusetts will be considered as part of the I-93 Traffic Corridor Study initiated by the Merrimack Valley Planning Commission in late September 2000).

- To be effective, an HOV lane in New Hampshire must extend into Massachusetts and would require an extensive infrastructure investment along the I-93 corridor in northern Massachusetts (an HOV option along I-93 in Massachusetts will also be considered as part of the I-93 Traffic Corridor Study being conducted by the Merrimack Valley Planning Commission in Massachusetts).

- The East and I-93 Basic Rail corridors generate between one-third and one-half the ridership of the Enhanced Rail Corridor depending on the number of travel lanes on I-93. These alternatives require much less infrastructure investment in Massachusetts than does the Enhanced Rail Corridor.

- The West Rail Corridor is not an effective rail option in addressing traffic issues along I-93.

- An HOV lane in New Hampshire-only does not generate HOV volumes that meet the recommended minimum operating threshold.

- An HOV lane in Massachusetts and New Hampshire generates HOV volumes that meet the recommended minimum operating threshold only south of Exit 1.

- Providing an HOV lane in Massachusetts and New Hampshire increases bus ridership substantially over having no HOV lane or an HOV lane only in New Hampshire.

6

Alternatives Recommended for Further Study

6.1 Summary of Recommendations

In an effort to narrow the broad range of alternatives proposed in the Scoping Report as possible ways to address the needs of the I-93 corridor between Salem and Manchester, NH, the NHDOT has evaluated the merits and potential of these alternatives. The evaluation has considered technical analysis and public input and environmental agency review. This section provides a summary of recommendations developed as a result of the technical evaluations completed, public input provided, and environmental review.

6.1.1 No Build

The No Build Alternative is not considered a viable alternative, but will serve as a baseline condition for comparison with other alternatives.

6.1.2 Mode Options

Based on the study of potential ridership and its affect on highway level of service, bus service, rail service and the use of HOV lanes either alone or in combination with each other, do not eliminate the need to widen the highway, if acceptable levels of service are to be achieved over the next 20-years, or over some intermediate time frame, say 2010. The mode options will help alleviate the length of time over which congestion occurs, but the peak hour of congestion will remain, and under many of the mode combinations tested, the 3+ hour period of congestion will remain. With this in mind, it is recommended that further consideration of HOV lanes and rail service be discontinued as part of this study. These measures do not result in enough diversion to influence the need to widen the highway and would result in major additional expenditures for construction and long term operation. They also require substantial investment by the State of Massachusetts.

Improvements in bus service, both in the form of expanded bus service and enhanced bus service, are proposed for further study. In addition, given the likelihood that rail service will be required to meet the future needs of transportation in the area served by I-93, it is proposed that space be reserved within the I-93 highway corridor for a possible future passenger rail line. By reserving such space, future opportunities for rail service, and possibly as an interim measure for bus service, would remain available.

6.1.3 Highway Widening

The initial highway widening concepts developed under this phase of the study, and identified in Chapter 4, section 4.4, incorporated a typical roadway cross section which included four 12 ft. travel lanes, a 10 ft. outside shoulder, a 14 ft. inside (HOV enforcement) shoulder and a 4 ft. painted buffer area between the two inner most travel lanes, in each direction. The inner most travel lane could be utilized as an HOV lane. This typical cross section was mirrored in the opposite direction for a total of 8 lanes or 4 lanes in each direction. The minimum median width between the two NB and SB barrels varied between approximately 60 ft. to 90 ft. so as not to preclude the potential for a future rail line down the median.

As previous noted, an HOV facility would not produce the minimum recommended ridership to make these lanes a feasible option. It was therefore recommended that the HOV lane option be dropped from further consideration as this study proceeds to more detailed widening evaluations. This would result in a reduction in width of 6 ft. in each direction, or a total of 12 ft in the overall corridor width.

As such, the I-93 mainline improvements identified in Chapter 4, section 4.4.1, will be investigated in more detail (albeit, at a narrow width) in the next phase of study. Of the three different widening concepts developed between Exits 1 and 2 to minimize or avoid impacts to Porcupine Brook:

Concept 1 - (Figures 4.4-3 to 4.4-7) constructing a new NB barrel to the east, widening the SB barrel to the west and providing for a future rail line on the existing NB barrel,

Concept 2 - (Figures 4.4-8 to 4.4-10) widening the existing NB barrel to the east, widening the SB barrel to the west and providing for a future rail line within the median, and

Concept 3 - (Figures 4.4-11 to 4.4-14) widening the existing NB barrel to the east, widening the SB barrel to the west and providing for a future rail line to the west,

Concept 2 will be carried forward for more detailed evaluation. By observation, this concept has the least impacts.

The remaining I-93 mainline concepts (Figures 4.4-15-4.4-31) will be carried forward and evaluated in more detail to try and minimize or avoid impacts to important resources, while at the same time provide practicable alignments both in terms of construction and long term operation.

The I-93 interchange improvements identified in Chapter 4, Section 4.4.2, will also be investigated in more detail during the next phase of study: :

Exit 1 Concepts - (Figures 4.4-32 to 4.4-33) Both concepts will be carried forward and evaluated further.

Exit 2 Concepts - (Figures 4.4-34 to 4.4-35) Both concepts will be carried forward and evaluated further.

Exit 3 Concepts - (Figures 4.4-36 to 4.4-43) All concepts will be carried forward and evaluated further except for the proposed 1995 design concept developed for Exit 3 back in 1995 (Figure 4.4-36), which included a flyover ramp. This concept will not be carried forward as other options evaluated provide satisfactory levels of service with fewer impacts.

Exit 4 Concepts - (Figures 4.4-44 to 4.4-45) Both concepts will be carried forward and evaluated further.

Exit 5 Concepts - (Figures 4.4-46 to 4.4-48) All three concepts will be carried forward and evaluated further.

6.1.4 TSM Improvements

The TSM improvements identified in Chapter 4, section 4.5 (Figures 4.4-15-4.4-31), will all be carried forward for more detailed evaluation except for shoulder lane use (Section 4.5.3) and ramp metering (Section 4.5.2). The conclusions of the evaluation for shoulder lane use do not support continued evaluation based on safety, cost and construction scheduling issues. Ramp metering is not proposed for additional study as its effectiveness relative to improving I-93 would be limited to the SB barrel in the morning peak period, and backups on secondary roads within the interchange area would be excessive.

The remaining TSM measures identified will be developed in greater detail to determine impacts and estimate potential time frames for when these minor improvements could be implemented.

6.1.5 TDM Measures

TDM measures identified in Chapter 2, Section 2.2.3, with exception of Congestion Pricing (Section 2.2.3.2), will be carried forward for more detailed evaluation. Congestion pricing is not proposed for further study as it would do little to address current congestion levels, there is a lack of alternative routes or modes, and it would likely be reviewed as a regressive tax and incompatible with New Hampshire's quality of life.

Park and ride lots at Exits 2, 3 and 5 along with a proposed expansion to the existing lot at Exit 4 will be considered further. These initial concepts will be developed in more detail and refined, as appropriate, to minimize impacts and maximize use.

6.2 Alternatives Carried Forward Into DEIS

The following alternatives will be carried forward into the development of the Draft Environmental Impact Statement (DEIS), for further detailed evaluation.

- The No-Build alternative which essentially serves as a basis for purposes of comparison with the Build alternatives.

- Transportation Systems Management (TSM) measures which are minor improvements that can be accomplished within the existing ROW at minimal expense. Such measures generally do not address the project purpose and need, but may help to alleviate problems in the near term.

- Widening I-93 to 4-lanes in each direction the entire length of the corridor. In addition, constructing or expanding park and ride lots at Exits 2, 3, 4, and 5 and providing room and, as practical, constructing sub-grade for future transit service within the highway corridor is proposed.

- Widening I-93 to 3-lanes in each direction for the entire length of the corridor, in addition to the same park and ride lot construction and provision for future transit service as noted with the previous widening alternative.

- Widening I-93 to 4-lanes in each direction south of Exit 3 and 3-lanes in each direction north of Exit 3, along with the provisions proposed with the other widening schemes.

- Transportation Demand Management (TDM) measures which involve employer based measures utilizing incentives and disincentives to encourage people to not drive alone.

- Improvements in bus service in keeping with expanding existing service and providing an enhanced service to employment centers in northern Massachusetts.

These alternatives will be evaluated in more detail to determine associated impacts, which will be documented in the DEIS. Following distribution of the DEIS for review and comment, the NHDOT will hold a Public Hearing and identify a preferred alternative. The Public Hearing will be conducted jointly with the New Hampshire Department of Environmental Services (NHDES) Wetlands Board and the US Army Corps of Engineers.

Upon completion of a successful Public Hearing, comments on the DEIS and input received from the hearing will be addressed in a Final Environmental Impact Statement (FEIS). The FEIS will identify the NHDOT's selected alternative for this segment of the I-93 corridor.